Pattern-based GIS for understanding content of very large Earth Science datasets

Completed Technology Project (2015 - 2017)

Project Introduction

The research focus in the field of remotely sensed imagery has shifted from collection and warehousing of data ' tasks for which a mature technology already exists, to auto-extraction of information and knowledge discovery from this valuable resource ' tasks for which technology is still under active development. In particular, intelligent algorithms for analysis of very large rasters, either high resolutions images or medium resolution global datasets, that are becoming more and more prevalent, are lacking. We propose to develop the Geospatial Pattern Analysis Toolbox (GeoPAT) a computationally efficient, scalable, and robust suite of algorithms that supports GIS processes such as segmentation, unsupervised/supervised classification of segments, query and retrieval, and change detection in giga-pixel and larger rasters. At the core of the technology that underpins GeoPAT is the novel concept of pattern-based image analysis. Unlike pixel-based or object-based (OBIA) image analysis, GeoPAT partitions an image into overlapping square scenes containing 1,000'100,000 pixels and performs further processing on those scenes using pattern signature and pattern similarity ' concepts first developed in the field of Content-Based Image Retrieval. This fusion of methods from two different areas of research results in orders of magnitude performance boost in application to very large images without sacrificing quality of the output. GeoPAT v.1.0 already exists as the GRASS GIS add-on that has been developed and tested on medium resolution continental-scale datasets including the National Land Cover Dataset and the National Elevation Dataset. Proposed project will develop GeoPAT v.2.0 ' much improved and extended version of the present software. We estimate an overall entry TRL for GeoPAT v.1.0 to be 3-4 and the planned exit TRL for GeoPAT v.2.0 to be 5-6. Moreover, several new important functionalities will be added. Proposed improvements includes conversion of GeoPAT from being the GRASS add-on to stand-alone software capable of being integrated with other systems, full implementation of web-based interface, writing new modules to extent it applicability to high resolution images/rasters and medium resolution climate data, extension to spatio-temporal domain, enabling hierarchical search and segmentation, development of improved pattern signature and their similarity measures, parallelization of the code, implementation of divide and conquer strategy to speed up selected modules. The proposed technology will contribute to a wide range of Earth Science investigations and missions through enabling extraction of information from diverse types of very large datasets. Analyzing the entire dataset without the need of sub-dividing it due to software limitations offers important advantage of uniformity and consistency. We propose to demonstrate the utilization of GeoPAT technology on two specific applications. The first application is a web-based, real time, visual search engine for local physiography utilizing query-by-example on the entire, global-extent SRTM 90 m resolution dataset. User selects region where process of interest is known to occur and the search engine identifies other areas around the world with similar physiographic character and thus potential for similar process. The second application is monitoring urban areas in their

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Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Center / Facility:

NASA Headquarters (HQ)

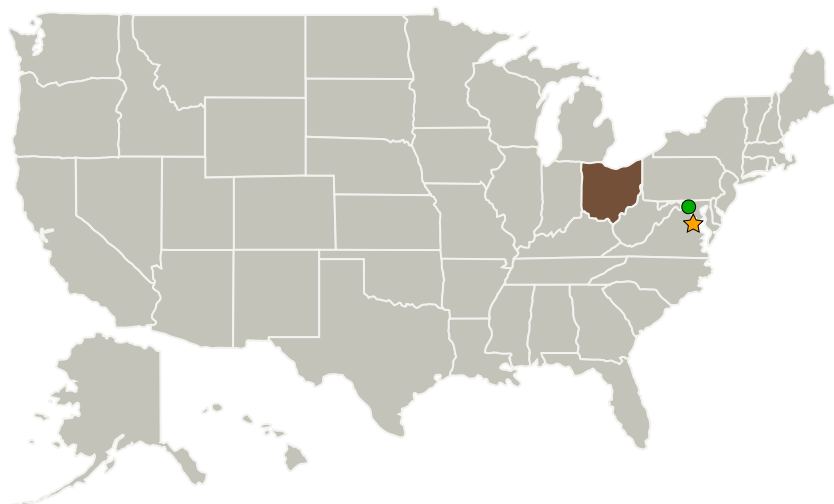**Responsible Program:**

Advanced Information Systems Technology

entirety at the high resolution including mapping of impervious surface and identifying settlements for improved disaggregation of census data.

Primary U.S. Work Locations and Key Partners

Organizations Performing Work	Role	Type	Location
⭐NASA Headquarters(HQ)	Lead Organization	NASA Center	Washington, District of Columbia
🟢Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland
University of Cincinnati-Main Campus	Supporting Organization	Academia	Cincinnati, Ohio

Primary U.S. Work Locations
Ohio

Project Management

Program Director:
Pamela S Millar

Program Manager:
Jacqueline J Le Moigne

Principal Investigator:
Tomasz Stepinski

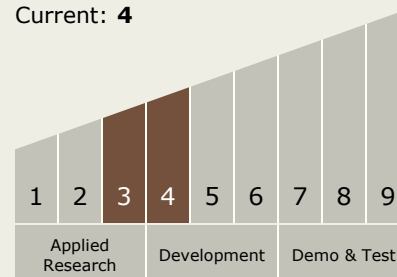**Co-Investigators:**
Jaroslaw D Jasiewicz
Jacek Niesterowicz
Pawel Netzel
Cynthia Treacy

Technology Maturity (TRL)

Start: **3**
Current: **4**

1	2	3	4	5	6	7	8	9
Applied Research			Development			Demo & Test		

Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - TX11.4 Information Processing
    - TX11.4.2 Intelligent Data Understanding

Target Destination
Earth